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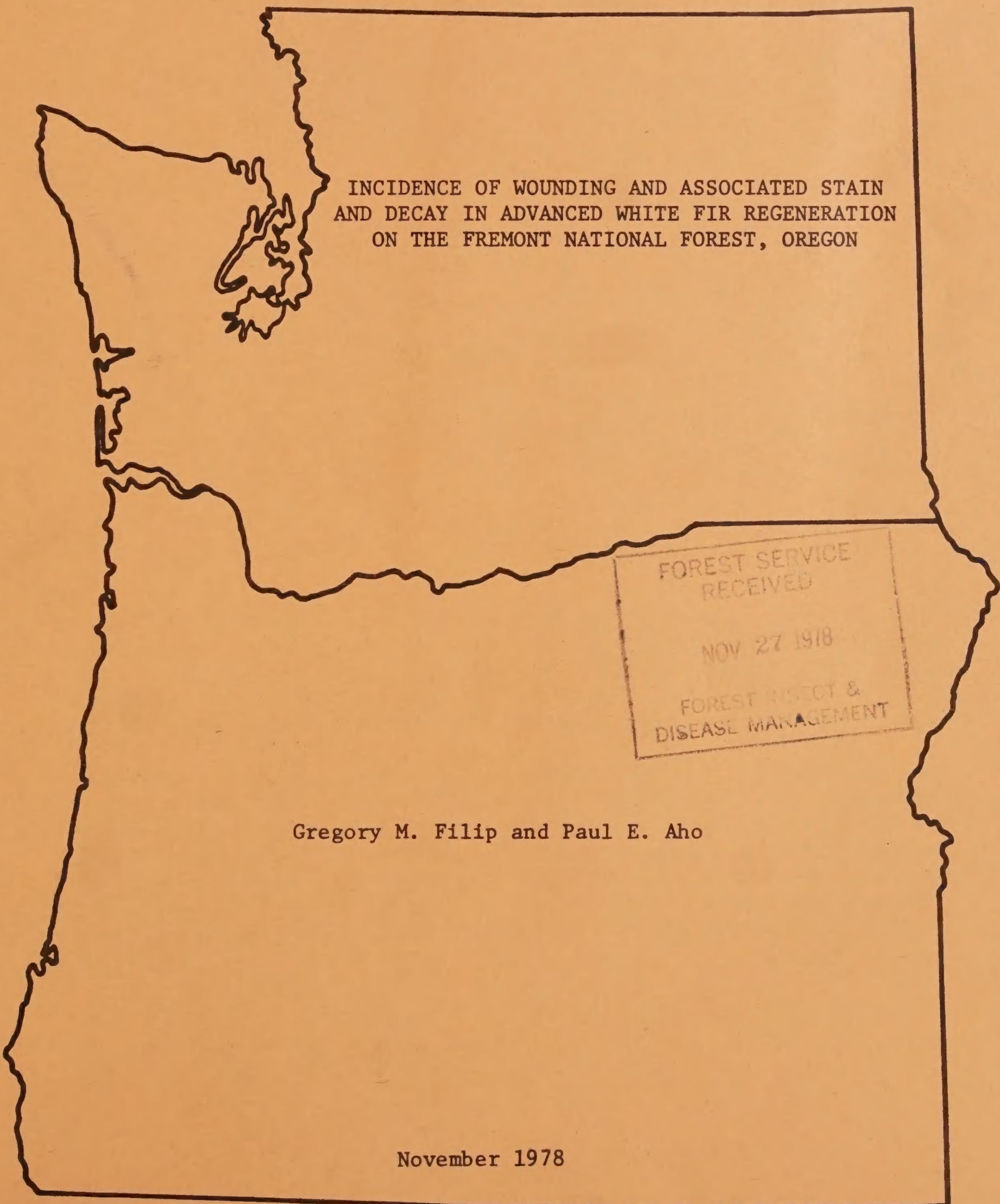

INCIDENCE OF WOUNDING AND ASSOCIATED STAIN AND DECAY IN ADVANCED WHITE FIR REGENERATION ON THE FREMONT NATIONAL FOREST, OREGON

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INCIDENCE OF WOUNDING AND ASSOCIATED STAIN AND DECAY IN ADVANCED WHITE FIR REGENERATION ON THE FREMONT NATIONAL FOREST, OREGON

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Abstract

Two hundred and one stems of advanced white fir regeneration in four stands on the Fremont National Forest were examined for wounds and dissected to determine presence and extent of decay. Isolations were made to identify decay-causing fungi. Half of all trees examined had at least one wound, 48 percent had wetwood, but only 3 percent had advanced decay.

Forty-one of the 201 trees were intensively examined. Nine trees (22 percent) were infected with *Echinodontium tinctorium*. This fungus was isolated from dead twigs in five trees, from advanced decay in two trees, from stain in one tree, and from healthy-appearing (no discoloration) stem pith in one tree. The dbh of trees with *E. tinctorium* infections averaged 4.5 inches and the age, 64 years, respectively. Recommendations for managing white fir regeneration with regard to decay are provided.

Introduction

White fir (*Abies concolor*) is a major component of many forest cover types in south-central Oregon. The species has many desirable characteristics--it is competitive, shade tolerant, reproduces well naturally, and grows rapidly when released from moderate suppression. Several National Forests in Region 6 are converting ponderosa (*Pinus ponderosa*) and lodgepole pine (*P. contorta*) stands to white fir for these reasons.

Studies have shown that white fir and another true fir species, grand fir (*A. grandis*), can be severely decayed, especially mature or overmature trees (Aho and Simonski 1975, Aho 1977).

Grand fir as young as 20 years of age have been reported to have advanced decay (Maloy and Gross 1963). This is generally an exception since decay in grand fir does not become significant in unmanaged stands until trees are at least 125 years old (Aho 1977).

Active decay associated with wounds in small advanced regeneration of Pacific silver fir (*A. amabilis*) and grand fir has been shown to be very low (Aho 1960, Herring and Etheridge 1976, Aho and Hutchins 1977). However, fungi with decay-causing potential but which are dormant have been isolated from healthy-appearing stem pith and encased branch piths of both suppressed Pacific silver fir (Herring and Etheridge 1976) and grand fir (Aho and Hutchins 1977). The amount of decay that will result from dormant decay fungi is unknown.

Basidiospores of these decay fungi, primarily *Echinodontium tinctorium* (ET), the Indian paint fungus, have been shown to infect suppressed western hemlocks through very small (0.1 in. diameter), dead, branchlets (Etheridge and Craig 1975). Dead branchlets are probably the primary infection courts for ET in suppressed white and grand fir also (Aho and Hutchins 1977).

Preliminary studies in the Blue Mountains of Oregon have shown that grand fir over 50 years old and overtopped by larger trees bearing ET conks have a high probability of being infected by ET.[1/] When dead branch traces heal, the fungus discontinues growth and becomes dormant in the pith tissues of branches or the main stem. Evidence is accumulating that injuries such as mechanical wounds, patch killing of bark by bark beetles, or death of tops or large branches activates dormant infections. Other decay fungi enter stems primarily through wounds, both natural and man-made. Decay fungi, particularly *Pholiota* sp. and *Hericium abietis*, enter primarily through basal and trunk wounds in old-growth grand fir (Aho 1977) and in intensively managed young stands (Maloy and Robinson 1968).

Forest managers need to know which potential decay fungi are present in advanced white fir regeneration and how much decay to expect at rotation age. They need to know decay volumes at intervals during the growing cycle since they may have to harvest before rotation age if losses are excessive. Decay losses will depend on several factors such as available fungus inoculum, stand history, site productivity, overstory species, amount of wounding, tree vigor, and tree genetics. Studies have not been conducted through an entire rotation of white fir to determine how much decay to expect under various circumstances in "X" number of years. At this point we can only identify high risk stands that may become seriously decayed before harvest.

Objectives of our evaluation of advanced white fir regeneration on the Fremont National Forest were to:

1. Determine the extent of wounding and measure stain and/or decay in sampled stems.

2. Determine which microorganisms are associated with stain and/or decay.

3. Determine if potential decay-causing fungi are present within healthy-appearing stem piths and twig piths in living and dead lower crown branches.

4. Determine if correlations exist between incidence of decay fungi and various tree and stand characteristics.

Methods

Stand Descriptions

Four stands on the Fremont National Forest, Oregon, were examined (two on Lakeview Ranger District, two on Silver Lake Ranger District, Figure 1). Stand 1 on the Lakeview Ranger District (Willow Creek Area; T. 40 S., R. 21 E., sec. 23) consisted of mature white fir with some ponderosa pine (Figure 2). Much of the overstory remained unharvested at the time of sampling and was severely infected with ET as noted by the presence of numerous conks on dead and overmature white fir (Figure 3). Understory trees consisted of scattered white fir saplings and poles.

Stand 2 on the Lakeview Ranger District (Barnes Rim Area; T. 39 S., R. 16 E., sec. 3) formerly consisted of mature white fir and some ponderosa pine that had been removed in several entries since 1930 (Figure 4). The sampled stand consisted of white fir poles that was precommercially thinned to an 18 x 18 foot spacing the year prior to our examination.

Stand 3 on the Silver Lake Ranger District (Stams Mt. Area; T. 25 S., R. 11 E., sec. 21) formerly consisted of mature white fir with some ponderosa and lodgepole pine that had been removed in 1977 (Figure 5). Several cull white fir with ET conks remained in the stand at the time of sampling. The sampled stand mainly consisted of white fir, lodgepole pine, and ponderosa pine saplings and poles.

Stand 4 on the Silver Lake Ranger District (Stams Mt. Area; T. 25 S., R. 11 E., sec. 28) was similar to Stand 3 regarding species composition and silvicultural treatment (Figure 6).

Tree Selection

In June 1977, trees were selected from the four stands as follows: A series of parallel transects 3 chains apart were delineated by compass across the stand. At 3-chain intervals along each transect line the best crop tree (white fir) nearest to the sample point was examined.

1/Unpublished data on file at the PNW Forest and Range Exp. Stn., Forestry Sciences Laboratory, Corvallis, Oregon.

Data collected for each tree included: (1) Height, (2) dbh, (3) age, (4) presence of all external defects, and (5) size (length and width), position (distance from ground to wound midpoint), and condition (open or closed) of each wound. Wounds were dissected to determine age and presence of stain and/or decay.

Extensive Tree Sampling

Each tree, regardless of damage, was cut at ground line and at 1-foot intervals along the trunk. Length and midpoint diameter of wetwood, stain, and decay columns were recorded. Sections of wood (3 x 3 x 3 inches) containing wetwood, stain, or decay were collected and refrigerated for 2-5 days before they were returned to the laboratory (Portland) for culturing. Wood chips were taken from freshly exposed sections of healthy-appearing, stained, or decayed wood and placed on 2 percent malt agar plates. Cultures were incubated for 6 weeks at room temperature after which the incidence of bacteria/yeasts, imperfect fungi, and basidiomycetous fungi was recorded.

Intensive Tree Sampling

Every fifth sample tree along transect lines was described as above. However, these trees were felled and bucked into 4-foot lengths to just above the lowest whorl of live branches of the crown. Bolts were sent to the Forestry Sciences Laboratory (Corvallis) in plastic bags 1-2 days after they were cut. Bolts were collected in Stands 1 and 2 in June and in Stands 3 and 4 in mid-November.

In the laboratory, bolts were cut into 4-inch sections and split longitudinally with a chisel. From each section isolations were made from stem pith areas and twig piths of living and dead branches. Twig piths were classified as occluded (buried), living, or dead. Twig diameter at the point of stem juncture was also recorded. Height of isolations from ground level, presence of stain or decay, and size, age, and position of associated wounds were also recorded. Isolations were placed on 2 percent malt agar slants and incubated at room temperatures for 6 weeks after which all microorganisms were identified as bacteria, yeasts, imperfect fungi, or basidiomycetous fungi.

Data were statistically analyzed by chi-square analysis.

Results

Extensive Tree Sampling

Two hundred and one white fir were examined on the Fremont National Forest (Table 1). Average dbh was 3.3 inches and age 74.3 years for four stands. Trees sampled on the Silver Lake Ranger District (Stands 3 and 4) were generally smaller and younger than those on the Lakeview Ranger District (Stands 1 and 2). Ninety-five percent of all trees were over 50 years of age.

There were a total of 214 wounds on 101 trees (Table 2). Fifty percent of all trees examined had at least one wound. Total number of wounds and

number of trees with wounds were greater in the Lakeview stands than in the Silver Lake stands, probably due to the precommercial thinning operation in Stand 2 (Table 2). There was a significantly higher percentage of closed (healed) wounds in the Silver Lake stands.

Wetwood was associated with 37 percent of all wounds (Figure 7). Only 2 percent of all wounds had associated advanced decay (Table 2). Stands on the Lakeview Ranger District appeared to have more wetwood associated with wounds than stands on the Silver Lake Ranger District, but differences were not statistically significant. There was significantly more wetwood associated with closed wounds than with open wounds, especially in Silver Lake stands.

Forty-eight percent of all white fir examined had wetwood (Table 3). Fifty-seven percent of the trees with wetwood were wounded while 43 percent were not. Only 3 percent of all trees had decay, and there was no correlation with presence of wounds.

Wounds in Lakeview stands were generally larger and more recent than those in Silver Lake stands (Table 4). The majority of wounds occurred 2 feet or more above the ground line.

Isolations from wetwood and incipient decay yielded very few (1 percent) decay fungi (Table 5). A high percentage of isolations were sterile (41 percent). Bacteria/yeasts (13 percent) and nondecay, imperfect fungi (45 percent) were commonly isolated.

Intensive Tree Sampling

Forty-one trees were dissected from which 3,573 isolations were attempted (Table 6). Twenty-five percent of all trees contained positively identified decay fungi, most of which were ET. Twenty-three of 3,573 (1 percent) were decay fungi. Most isolations (73 percent) yielded no microorganisms. Bacteria and yeasts were recovered from 22 percent and nondecay fungi from 4 percent of the isolations.

Nine of 41 trees (22 percent) contained infections of ET (Table 7). ET was isolated from dead twigs in five trees, from advanced decay in two trees, from stain in one tree, and from healthy-appearing stem pith in one tree. One tree with decay and another with stain were wounded.

The dbh of trees with ET infections average 4.5 inches and the age, 64 years, respectively (Table 7). Only one tree below 50 years of age had ET infections. All four stands had at least two trees with ET infections.

Ten of the 41 sample trees (25 percent) had at least one isolation of a probable decay fungus (including ET). *Hericium abietis* was isolated from dead twigs on two trees. Two other trees had advanced decay, but culturing yielded no decay fungi.

Discussion

Nearly 95 percent of our sampled trees were over 50 years old and 25 percent of those intensively examined yielded decay fungi, some already causing advanced decay. White fir that has been suppressed and is over 50 years of age appears to be highly susceptible to infection by ET through small branchlets. Fifty percent of our sampled trees had one or more wounds and half of these had not healed. Many of these wounds could still activate dormant ET infections in time, especially those which are still open. Additional wounding that will occur after future stand entries may further activate dormant decay fungi or introduce others.

Almost half of our sampled trees had wetwood, but no decay fungi were isolated from wetwood. In most cases wetwood will not decay since most of the trees we sampled had closed or no wounds.

Although most of the wounds we observed were fairly small, several were very large in size. Larger wounds take longer to heal than small wounds and thus allow more time for decay fungi to infect exposed wood. Most of the wounds were located more than 2 feet above the ground, especially in the precommercially thinned stand (#2). Several of these wounds may have resulted from felled trees striking residual trees.

Many of the dormant ET infections found in our investigation were isolated from dead branches within 2 inches of the main stem. As trees grow, dead branches are encased in expanding stemwood. Branches containing ET infections near the main stem could eventually be encased in stemwood as the tree continues to grow. Wounding may later activate these dormant infections.

Advanced regeneration of white fir in all stands examined has a high risk of becoming seriously defective before rotation age since most trees are already over 50 years old and 25 percent are already infected. However, we do not know how much decay to expect at rotation age since our present knowledge concerning defect prediction at rotation age is lacking. Other than pathological factors may play important roles in management decisions concerning advanced white fir regeneration. On sites where white fir is silviculturally adapted such as those with northern aspects, good growth accumulated by crop trees may compensate for loss by decay. On poor white fir sites, other species should be favored to prevent decay loss in low vigor white fir.

There is a definite need for additional research in this area. As data is collected throughout an entire rotation of true fir, our knowledge of stand treatments with respect to future decay will improve.

Summary

(1) Two hundred and one white fir in four stands on the Fremont National Forest were examined for wounds and dissected to determine extent of decay and decay-causing fungi.

(2) Ninety-one percent of all trees examined had at least one wound. Open wounds were as common as closed wounds.

(3) Fifty-eight percent of all trees examined had wetwood, a condition that seldom proceeds to decay, while only 3 percent of all trees had advanced decay.

(4) Ten of 41 trees (25 percent) that were intensively cultured contained positively identified decay fungi, most of which was ET.

(5) ET was isolated from dead twigs in five trees, from advanced decay in two trees, from stain in one tree, and from healthy-appearing stem piths in one tree.

(6) The dbh of trees with ET infections average 4.5 inches and the age, 64 years. All four stands had at least two trees with ET infections.

Recommendations

Stands containing advanced regeneration of white fir should be rated for potential to develop severe decay by considering situations that indicate high risk such as the following:

(1) Overstory of white fir infected with ET.

(2) Advanced regeneration that has been suppressed for over 50 years.

(3) Advanced regeneration that has numerous wounds.

(4) Advanced regeneration of low vigor because of poor site.

Stands where three or more of the above situations are present have a high potential for serious decay development. Advanced regeneration of other species should be favored in these stands or the regeneration destroyed and the site replanted. At least three of the above situations were present in all four of the stands we examined.

Each stand needs to be critically evaluated with the four situations in mind. For instance, although Stand 2 had an overstory of infected white fir and has numerous wounds (many are recent), the advanced regeneration has not been severely suppressed and is growing vigorously (even before thinning). This stand can probably be brought to rotation age without serious decay losses if the trees are not wounded again. Stands 1, 3, and 4 also had and still have ET-infected overstories, have numerous wounds although not as many as Stand 2, have been more severely suppressed, and are located on poorer sites than Stand 2. Infected overstories in these stands should be removed and advanced regeneration of pines and unwounded, thrifty white fir favored. All other regeneration should be destroyed and understocked areas replanted.

Pathologists and silviculturists from the Regional Office in Portland are available to assist in formulating management decisions in these and similar stands on the Forests.

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Literature Cited

AHO, P. E.
1960. Heart-rot hazard is low in *Abies amabilis* reproduction injured by logging. USDA For. Serv. Res. Pap. PNW-196, 5 pp., PNW For. and Range Exp. Sta., Portland, Oregon.

AHO, P. E.
1976. Fungal and bacterial associations in heart rots of *Abies concolor* (Gord. and Glend.) Lindl. and techniques for estimating damage in southwestern Oregon. Doctoral thesis, Oregon State Univ., Corvallis, Oregon. 202 pp.

AHO, P. E.
1977. Decay of grand fir in the Blue Mountains of Oregon and Washington. USDA For. Serv. Res. Pap. PNW-229, 18 pp., PNW For. and Range Exp. Sta., Portland, Oregon.

AHO, P. E., and A. Hutchins
1977. Microorganisms from the pith region of suppressed grand fir understory trees. USDA For. Serv. Res. Note PNW-299, 5 pp., PNW For. and Range Exp. Sta., Portland, Oregon.

AHO, P. E., and P. Simonski
1975. Defect estimation for white fir in the Fremont National Forest. USDA For. Serv. Res. Pap. PNW-196, 9 pp., PNW For. and Range Exp. Sta., Portland, Oregon.

ETHERIDGE, D. E., and H. M. Craig
1975. Factors influencing infection and initiation of decay by the Indian paint fungus (*Echinodontium tinctorium*) in western hemlock. Can. J. For. Res. 6:299-318.

HERRING, L. J., and D. E. Etheridge
1976. Advance amabilis-fir regeneration in the Vancouver Forest District. B. C. For. Serv./Can. For. Serv. Joint Report No. 5, 23 pp.

MALOY, O. C., and H. L. Gross
1963. Decay in young grand fir. J. For. 61:850-853.

MALOY, O. C., and V. S. Robinson
1968. Microorganisms associated with heart rot in young grand fir. Can.J. Bot. 46:306-309.

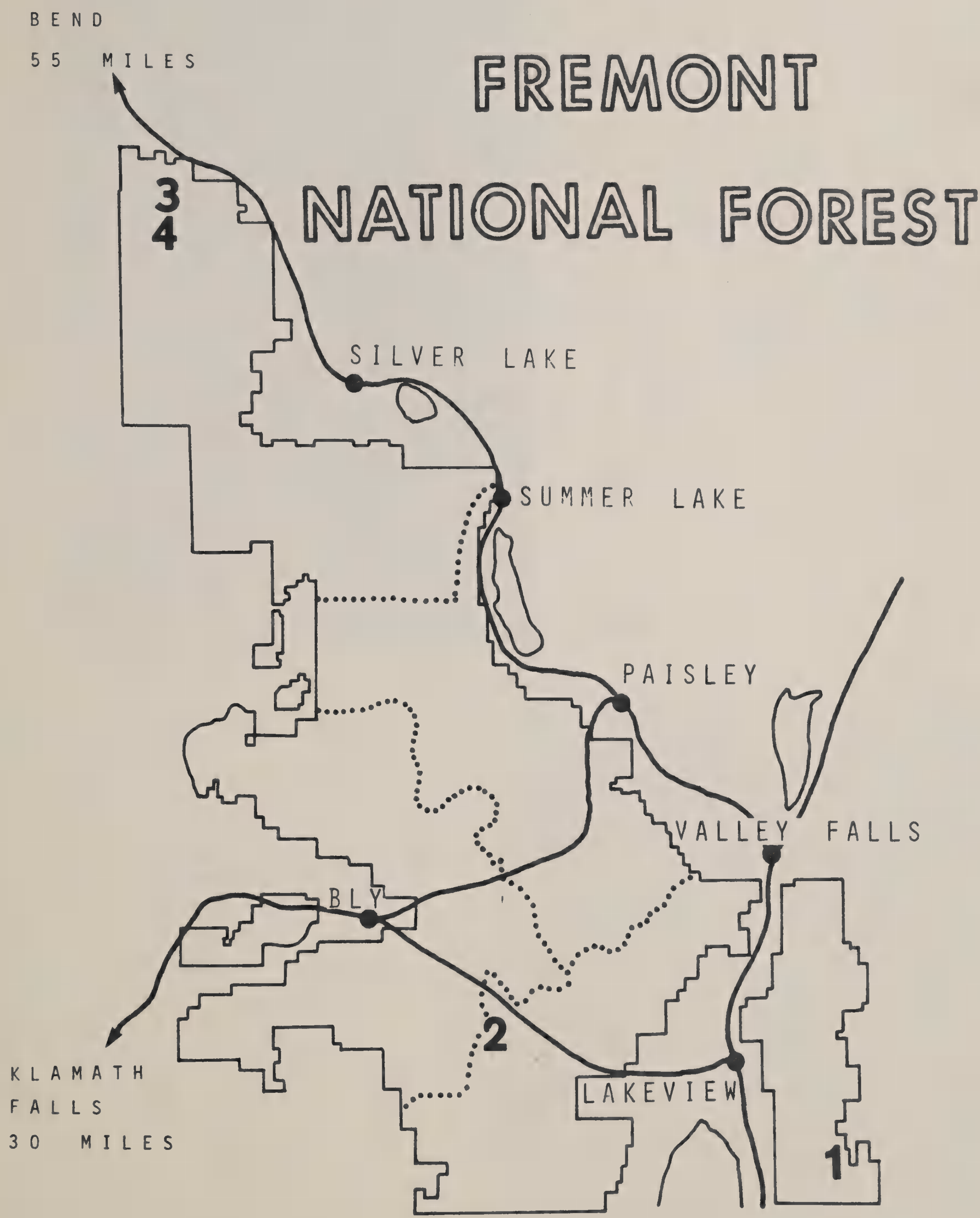

Figure 1--Location of the sampled stands on the Fremont National Forest.

Figure 2--Stand #1 on the Lakeview Ranger District.

Figure 3--Sporophore of Echinodontium tinctorium on an infected old-growth white fir.

Figure 4--Stand #2 on the Lakeview Ranger District.

Figure 5--Stand #3 on the Silver Lake Ranger District.

Figure 6--Stand #4 on the Silver Lake Ranger District.

Figure 7--Wetwood (dark circular area) within stem of white fir.

Table 1--Height, DBH, age, and number of trees over 50 years old from 201 white fir on the Fremont National Forest

Stand Locality	Total Number of Trees	Height (ft.)		DBH (in.)		Age (yrs.)		Number of Trees Over 50 Years Old	Number of Trees With Scars
		Ave.	Range	Ave.	Range	Ave.	Range		
Lakeview RD (1)	50	16.4	5.9-28.3	3.5	1.0-5.9	82.3	32-145	49	23
Lakeview RD (2)	50	22.4	9.6-36.0	4.4	2.1-6.0	73.4	39-107	48	33
Silver Lake (3) RD	50	16.8	5.2-43.7	2.8	0.5-6.4	73.0	39-153	46	15
Silver Lake (4) RD	51	14.4	6.2-34.7	2.4	0.7-7.6	68.5	30-82	47	30
Total	201	17.6	5.2-43.7	3.3	0.5-7.6	74.3	30-153	190 (95%)	101 (50%)

Table 2--Number of wounds associated with wetwood and decay in 201 white fir on the Fremont National Forest.

		All Wounds			Open Wounds			Closed Wounds		
Stand Locality	Number of Trees With Wounds	Total Number	Number With Wetwood	Number With Decay	Total Number	Number With Wetwood	Number With Decay	Total Number	Number With Wetwood	Number With Decay
Lakeview RD (1)	23	49	19	0	29	11	0	20	8	0
Lakeview RD (2)	33	91	32	5	43	16	5	48	16	0
Sliver Lake RD (3)	15	23	9	0	10	0	0	13	9	0
Silver Lake RD (4)	30	51	19	0	24	1	0	27	18	0
Total	101	214	79	5	106	28	5	108	51	0
Percent	50		37	2	50	26	5	50	47	0

Table 3--Number of white fir with wetwood and decay on the Fremont National Forest.

Stand Locality	Total Number of Trees	Number of Trees with Wetwood			Number of Trees with Decay		
		Total	Wounded	Not Wounded	Total	Wounded	Not Wounded
Lakeview RD (1)	50	33	13	20	0	0	0
Lakeview RD (2)	50	28	20	8	5	3	2
Silver Lake RD (3)	50	19	8	11	1	0	1
Silver Lake RD (4)	51	15	13	2	0	0	0
Total	201	95	54	41	6	3	3
Percent		48	57	43	3	50	50

Table 4--Area, age, and bole position of wounds on 201 white fir on the Fremont National Forest.

Stand Locality	Area (sq. in.)		Age (yrs.)		Number of Wounds at Three Locations (ft.) Above Ground		
	Ave.	Range	Ave.	Range	0.0-0.5	0.6-2.0	2.0+
Lakeview RD (1)	13.7	0.4-101.0	13.3	1-82	9	5	35
Lakeview RD (2)	16.5	0.3-240.0	14.2	1-55	5	14	72
Silver Lake RD (3)	5.1	0.1- 39.0	21.2	1-61	4	10	9
Silver Lake RD (4)	3.0	0.2- 22.5	15.1	1-74	9	19	23
Total	11.4	0.1-240.0	14.9	1-82	27	48	139

Table 5--Microorganisms isolated from wetwood and incipient decay from 81 white fir on the Fremont National Forest.

Stand Locality	Total Number of Trees	Number of Trees with Positive Decay Fungi	Number of Isolation Attempts	Number of Isolations Yielding			
				No Growth	Bacteria or Yeasts	Nondecay Fungi	Decay Fungi
Lakeview RD (1)	21	0	125	50	4	71	0
Lakeview RD (2)	21	0	105	17	12	76	0
Silver Lake RD (3)	21	1	130	66	23	38	3
Silver Lake RD (4)	18	1	105	56	23	25	1
Total	81	2	465	189	62	210	4
Percent		2		41	13	45	1

Table 6--Microorganisms isolated from stem piths, twig piths, and dead branches of 41 white fir on the Fremont National Forest.

Stand Locality	Total Number of Trees	Number of Trees with Positive Decay Fungi	Number of Isolation Attempts	Number of Isolations Yielding: No Growth	Bacteria or Yeasts	Nondecay Fungi	Decay Fungi
Lakeview RD (1)	10	3	1,061	716	290	31	10
Lakeview RD (2)	10	3	969	805	115	31	5
Silver Lake RD (3)	10	2	651	428	153	49	4
Silver Lake RD (4)	11	2	892	668	181	32	4
Total	41	10	3,573	2,617	739	143	23
Percent		25		73	22	4	1

Table 7--Characteristics of nine white fir infected with _Echinodontium tinctorium_ and location of isolations within each tree.

Tree Characteristics Stand-Tree Number	DBH (in.)	Age (yrs.)	Location of Isolations
3 - 40	2.9	39	1.2 in. dead twig at 23.9 in. above ground
1 - 10	3.5	51	0.5 in. dead twig at 94.3 in. above ground
4 - 30	6.9	58	Stain with wound at 2.0-13.7 in. above ground
2 - 50	6.5	61	Decay assoc. with wounds at 0-29.7 in. and 41.0-47.2 above ground
1 - 41	4.4	71	0.3 in. dead twig at 37.0 in. above ground
2 - 10	5.1	74	Stem pith at 1.2 in. above ground
2 - 35	5.4	74	Decay at 43.7-46.0 in. above ground
3 - 45	1.6	75	1.2 in. dead twig at 28.4 in. above ground
4 - 45	4.2	76	0.6 in. dead twig at 65.1 in. above ground
Ave.	4.5	64	